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for

QUADRILATERAL SYMMETRICAL LIGHT SOURCE

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QUADRILATERAL SYMMETRICAL LIGHT SOURCE

RELATED APPLICATION

This application claims priority from Provisional Application No. 60/448,090 filed on February 19, 2003 which is incorporated by reference.

FIELD OF INVENTION

The present invention relates generally to the field of light sources. More specifically, the present invention is directed to a light source having a quadrilateral symmetrical reflector to allow focused light output.

BACKGROUND OF INVENTION

Light emitting diodes (LEDs) are well known solid state light sources. LEDs have many advantages over traditional sources such as incandescent bulbs as they are cheaper to produce, are more robust, and require less power. Other current alternative light sources include xenon lamps which increase light output but require a high operating voltage and has a limited life span. However, traditional light sources are used for numerous applications which take advantage of some of the characteristics of the light source but are often limited by other characteristics as well.

Traditional light sources have different thermal, optical and geometric limitations that differ greatly from light emitting diodes (LED). These differences may include maximum operating temperature for example. These differences have limited the use of LEDs in traditional lighting applications.

The use of LEDs to replace tradition light applications has been desired, but adaptation of the LEDs to a traditional lighting mounting arrangements has been difficult. In particular, a well defined beam is needed for applications such as obstruction lighting, including FAA lights L864, L810 and L865, marine navigational light and landscape lighting. The current LED light sources have reflectors designed much like reflectors for traditional lighting sources. These reflectors have rotational symmetry and thus cannot focus the light of the LED in order to satisfy the above mentioned applications.

Thus, there is a need for a lighting system which provides the means to use a LED in traditional lighting system applications. There is a further need for a lighting mount which allows an overlap in focused beams. There is yet another need for a modular lighting unit which can use less units to generate the same amount of light.

SUMMARY OF THE INVENTION

These needs and others may be met by the present invention, an example of which is a directed light source for efficient light emission. The light source has a planar substrate having a top surface and an opposite bottom surface. A light emitting device is located on the top surface of the planar substrate. A clear reflector has a back surface facing the top surface of the planar substrate and a semi-cylindrical front surface. The reflector includes a reflecting top surface and an opposite and quadrilaterally symmetrical reflecting bottom surface. The reflector causes light from the light emitting device to be directed out from the cylindrical front surface at a predefined angle.

Another example of the present invention is a reflector for focusing light emitted from a light source in a generally planar direction. The reflector includes a semi-cylindrical front surface and a back surface with an indentation which is shaped to cover the light source. A top reflecting surface is divided into two quadrants. A bottom reflecting surface is divided into two quadrants. The top quadrants and bottom quadrants are symmetrical in shape and reflect light emitted from the light source in a substantially horizontal plane.

Another example of the present invention is a reflector for focusing light emitted from a light source in a generally planar direction. The reflector has a curved front surface and a back surface in proximity to the light source. A top reflecting surface is divided into two quadrants and a bottom reflecting surface is divided into two quadrants. The top quadrants and bottom quadrants are symmetrical in shape and reflect light emitted from the light source in a substantially horizontal plane out of the front surface.

It is to be understood that both the foregoing general description and the following detailed description are not limiting but are intended to provide further explanation of the invention claimed. The accompanying drawings, which are incorporated in and constitute part of this specification, are included to illustrate and provide a further understanding of the method and system of the invention. Together with the description, the drawings serve to explain the principles of the invention.

BRIEF DESCRIPTION OF DRAWINGS

These and further aspects and advantages of the invention will be discussed more in detail hereinafter with reference to the disclosure of preferred embodiments, and in particular with reference to the appended Figures wherein:

FIG. 1 is a perspective view of a lighting device using the improved reflector according to one example of the present invention;

FIG. 2 is a perspective view of the improved reflector of the lighting device in FIG. 1;

FIG. 3 is a front view of the improved reflector of the lighting device in FIG. 1;

FIG. 4 is a back view of the improved reflector of the lighting device in FIG. 1;

FIG. 5 is a cross section view of the reflector in FIG. 1 which shows the emission of light rays from the lighting device;

FIG. 6 is a perspective view of an alternate reflector which is another example of the present invention;

FIG. 7 is a front view of the reflector shown in FIG. 6;

FIG. 8 is a back view of the reflector shown in FIG. 6;

FIG. 9 is a side perspective view of a masthead light assembly incorporating a multiple number of reflector light sources similar to that shown in FIG. 1;

FIG. 10 is a top perspective view of the masthead light assembly in FIG. 9;

FIG. 11 is an exploded view of a side mounting structure for the masthead light assembly in FIG. 9; and

FIG. 12 is a circuit diagram for the LEDs shown in the masthead light assembly in FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

While the present invention is capable of embodiment in various forms, there is shown in the drawings and will hereinafter be described a presently preferred embodiment with the understanding that the present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated.

FIG. 1 shows a lighting device 10 which is one example of the present invention. The lighting device 10 is centered around an LED 12 which is any semi-conductor, solid state light source such as a flat LED. The LED 12 will preferably have a lambertian distribution for the widest angle distribution of light. The LED 12 is coupled to a power source via two electrical leads 14 and 16. The LED 12 is affixed to a planar substrate 18. The planar substrate 18 is typically made from a highly thermally conductive material such as aluminum. The planar substrate 18 has a backing surface 20 with an opposite semi-cylindrical front surface 22. Of course other curved shapes may be used. A reflector 24 which is fabricated from a clear material such as PMMA, plexglass, glass or plastic is mounted on the front surface 22.

The substrate 18 can also be mounted to a heat spreader 26 coupled to a heat sink 28 to aid in heat dissipation from the LED 12. The substrate 18 with the heat spreader 26

and the heat sink 28 is ideally exposed to the surrounding environment or incorporates some heat dissipating device or devices such as a standard heat sink or another design using extruded metal (not shown).

Of course, multiple LEDs may be affixed to the planar substrate 18 below the reflector 24 in order to increase light output if desired. The LED 12 in this embodiment is a Luxeon LED available from Lumileds. Alternatively, the LED 12 may be a pre-packaged part such as a surface mount (SMT) or a though hole package, or an LED chip mounted directly to the substrate (chip on board, COB). The wavelength of the light is controlled by the material properties such as doping level and energy gap or by a florescencing overcoat on the LED 12. Of course conventional light sources may be used such as tungsten halogen and incandescent bulbs with the appropriate modifications to the reflector 24. The LED 12 includes an LED die 29 which is mounted on a reflective cup 30 which is formed on the substrate 18 to increase the beam intensity. The reflective cup 30 may be fabricated from any material with a specular finish.

The reflector 24 has a semi-cylindrical front surface 32. A symmetrical top 34 and bottom 36 have angled reflective surfaces 38 and 40 respectively. The angled surfaces 38 and 40 of the reflector 24 can either be specular or total internal reflection (TIR) based. Both of these types can have a smooth and/or faceted surface to control beam distribution and/or uniformity from the LED 12.

The smooth surfaces of the angled reflective surfaces 38 and 40 may be comprised of any one or more of the following surfaces; parabolic, elliptical, spherical or

high/low order mathematical function with the LED 12 located near the apex. Both of these design types are usually optimized for a far field pattern to reduce power consumption. If the reflector 24 is TIR based then the shape of the surfaces 38 and 40 are determined by the law of total internal reflection as no other material other than the bulk material of the reflector 24 is used to reflect the light. In the case of specular based reflection, a mirror coating such as aluminum may be evaporated on the surfaces 38 and 40 or a material such as chrome may be sprayed on the surfaces 38 and 40.

In applications such as a tail light with a wide beam pattern, it is desirable to form facets on the surfaces 38 and 40. The facets are typically comprised of concentric and/or planer facets with respect to the LED 12. The facets are then formed on the surfaces 38 and 40 by breaking the surfaces 38 and 40 in to planar or curved segments.

The reflector 24 has an opposite backing surface 42. The backing surface 42 has a pair of tabs 44 and 46. The tabs 44 and 46 provide mounting areas to the substrate 18. The tabs 44 and 46 have mounting holes 48, 50, 52 and 54 that may be used to hold fasteners such as screws or rivets to fix the reflector 24 to the substrate 18 in proper alignment with the LED 12. Of course other means may be used to couple the reflector 24 and the substrate 18.

The reflector 24 also has an indentation 56 on the back surface 42 which is fitted to the substrate 18. The indentation 56 has a pair of opposite semi-cylindrical top and bottom refractive surfaces 58 and 60 that are located around a lens 62 which covers the

LED die 29 which further collects light from the LED die 29. The indentation 56 is of sufficient size to accommodate the LED 12 including the lens 62.

The reflector 24 is preferably fabricated from PMMA /plexiglass, but any other clear material may be used such as glass. The reflector 24 is fabricated to employ quadrilateral symmetry as opposed to rotational symmetry. Thus the top reflective surface 58 is defined by quadrants 70 and 72 while the bottom reflective surface is defined by quadrants 74 and 76. The quadrilateral symmetry makes each quadrant 70, 72, 74 and 76 of the reflector 24 a mirror/rotated image of itself. Thus, quadrants 70 and 72 are mirror images, while quadrants 74 and 76 are mirror images. This is the same symmetry present in a rectangle but, unlike a rectangle which is planarly shaped, the reflector 24 has a curvature in the form of the reflective surfaces 38 and 40. The curvature is dictated by the radiation pattern of the LED 12 so optimally all the light is collected and is typically emitted in a 180 degree angle arc about the LED 12. A parabola profile is selected for the shaping the quadrants 70, 72, 74 and 76 and the outer surface 32 is shaped in a half torus. The focus of the quadrants 70, 72, 74 and 76 are preferably located at the focal smear of the LED 12. The refractive index of the material of the reflector 24 also influences the location of the focal smear of the LED 12.

The indentation 56 allows light rays from the LED 12 to be emitted through the reflector 24 at perpendicular angles to the surface 32. This allows the light rays to be refracted from the surfaces 58 and 60 with little or not change in angle. Alternatively, the indentation 56 may be made with a straight wall to allow the light to refract at the media

surface. The refraction is governed by Snell's law of refraction and thus the refraction at the surfaces of the indentation 56 changes the angle of the light and thus the location of the focal smear.

Furthermore, with a TIR based reflector the lens 62 is added to refract the light that is not collected by the TIR surfaces 38 and 40 of the reflector 24. The lens 62 may have either or a combination of the following surfaces: flat, convex, fresnel or concave that helps meet a beam distribution or lighting effect. In this example the lens 62 is a convex internal allowing for a greater collection of light.

In operation the shape of the reflector 24 allows the light from the LED 12 to be emitted in a horizontal plane from the front surface 32. Light that is emitted in the vertical plane at angles greater than the desired emission angle in the horizontal plane, is reflected back by the reflective surfaces 38 and 40. FIG. 5 is a cross section of the reflector 24 which shows light rays emitting from the LED 12. A series of light rays 80 are refracted by the upper refractive surface 58 and reflected by the top surface 38 to be emitted in a focused plane. A series of light rays 82 are refracted by the lower refractive surface 60 and reflected by the bottom surface 40 to be emitted in a focused plane. A series of light rays 84 which miss the reflective surfaces 38 and 40 are focused by the lens 62.

FIGs. 6-8 shows a reflector 100 which is another example of the present invention which may be used with the LED 12 mounted on the substrate 18 shown in FIG. 1. The reflector 100 is fabricated from PMMA/Plexiglass material but any clear material may be

used. The reflector 100 has a semi-cylindrical front surface 102 and an opposite backing surface 104. The cylindrical front surface 102 is divided into a top portion 106 and a bottom portion 108 by a cylindrical toroidal lens 110. The cylindrical toroidal lens 110 has the function of collimating or focusing light emitted from the LED 12 to substantially parallel to the horizontal plane.

The top portion 106 has a pair of vertical tabs 112 and 114 with mounting holes 116 and 118 respectively. The bottom portion 108 has a pair of vertical tabs 120 and 122 with mounting holes 124 and 126 respectively. The tabs 112, 114, 120 and 122 provide mounting surfaces to contact the substrate or another surface for placing the light device. The mounting holes 116, 118, 124 and 126 provide for the installation of fasteners such as screws or rivets to hold the reflector 100 in place.

The top portion 106 has a roughly parabolic reflective surface 128 while the bottom portion 108 has an opposite roughly parabolic reflective surface 130. The reflective surfaces 128 and 130 are TIR but may be specularly based or have facets as explained above.

The reflector 100 also has an indentation 138 on the back surface 104 which is rectangular in shape. The indentation 138 forms a flat surface 140 which has a semi-cylindrical cavity 142 for the light device such as the LED 12. The cavity 142 follows the rotational symmetry of the outer surface 102.

Furthermore, the TIR based reflector surfaces 128 and 130 allow a lens 144 to be added to refract the light that is not collected by the TIR surfaces 128 and 130 of the

reflector 100. The lens 144 can have a number of different surfaces that help meet a beam distribution or lighting effect. In this example the lens 144 is cylindrical.

As with the above example, the shape of the reflector 100 and the quadrilateral symmetry allows the light from a light source in the cavity 142 to be emitted in a horizontal plane from the outer surface 102. The cylindrical toroidal lens 110 assists in collimating the light and focusing the intensity in the horizontal plane at a specific emission angle. Light which is emitted in the vertical plane at angles greater than the desired emission angle in the horizontal plane is reflected back by the reflective surfaces 128 and 130. As explained above, the reflector 100 has quadrilateral symmetry for the reflective surfaces 128 and 130 which are divided into quadrants 150, 152, 154 and 156. The quadrants 150, 152, 154 and 156 of the reflector 100 are a mirror/rotated image of themselves. The curvature of the reflective surfaces 128 and 130 is dictated by the radiation pattern of the intended light source so optimally all the light is collected and is typically a 180 angle arc about the light source.

For higher lighting intensities or redundancy these light modules as shown in FIGs. 1-5 or 6-8 can be stacked on top of each other, side by side, or in a radial fashion or any combination of the three. This produces overlapping beam patterns that increases or completes a given beam angle specification.

FIGs. 9-10 shows a masthead antenna light 200 which incorporates multiple light modules as explained above. The masthead antenna light 200 is intended to emit powerful beams of light in certain specified angles to mark the position of an antenna

masthead for aircraft or ships. The antenna masthead light 200 has a circular base support 202 which is mountable atop an antenna masthead. The circular base support 202 has a flat mounting surface 204 which supports a pair of side structures 206 and 208 and an opposite pair of side structures 210 and 212. A front structure 214 is also mounted on the flat mounting surface 204. The side structures 206, 208, 210 and 212 are identical to each other.

Each of the structures 206, 208, 210, 212 and 214 has a light array 216 which has a multiple number of reflector and light source assemblies similar to the light device 10 described above in FIGs. 1-4. Each of the structures 206, 208, 210, 212 and 214 has a respective heat sink 218 which is used to dissipate heat generated by the lights and as a base mount for the structures 206-214. The light assembly 200 is designed to emit light at an approximate 225 degree angle forward. The light array 216 mounted on the front structure 204 emit light over approximately 180 degrees. The light arrays 216 mounted on the side structures 206-214 are shuttered using a series of apertures 220 which restrict the light emission to the desired 225 degree angle forward.

The side structure 206 will now be described with reference to FIG. 11. The side structure 206 has a vertical backing support 224 which has a front surface 226 and a back surface 228. The backing support 224 has a series of mounting holes 230 which corresponding to the mounting holes on a reflector similar to the reflector 24 shown in FIGs. 1-4. The backing support 224 serves as a heat sink and is coupled to the heat sink 218 which also has a hole 232 therethrough for installation of electrical connections and

wiring. A series of five LED light source assemblies 234 similar to the light source 10 shown in FIGs. 1-4 are mounted on the front surface 226 of the back support 224. The light assemblies 216 each have a LED 236 which is mounted on a heat spreader 238. The heat spreader 238 and LED 236 are in turn mounted on the front surface 226. A reflector 240 is installed over the LED 236. The reflector 240 allows the focusing of light emitted by the LED 236 in a planar beam and emits light over a 180 degree forward range.

FIG. 12 is a circuit diagram of the power of the electronic components for the masthead light 200 which is coupled to a power source 250. The LEDs of the light assemblies 216 on the side structures 206 and 208 are powered by a constant current controller 252 which is coupled to a power source 250. The LEDs of the light assemblies 216 on the side structures 210 and 212 are powered by a constant current controller 254 which is coupled to a power source 250. The LEDs of the light assemblies 216 on the front structure 214 are powered by a constant current controller 256 which is coupled to a power source 250. The constant current controllers 252, 254 and 256 convert alternating current into a 350 mA current in this example, but any suitable regulated power supply may be used.

In operation each of the light assemblies 216 emits a beam of light over a specific angle. Thus, the side mountings 206 and 208 have a series of ten LEDs in the light assemblies 216 which emit light over a narrow horizontal plane directly from the side mountings 206 and 208 due to the apertures 220. Similarly the LEDs of the light assemblies 216 attached to the side mounting assemblies 210 and 212 emit light over a

narrow horizontal plane directly from those mountings due to the apertures 220. The front mounting 214 similarly has ten light devices which emit light ahead of the front mounting 214. In this manner, light is emitted in a 225 degree arc from the masthead antenna light assembly 200. Of course, more or less light devices may be mounted for different light intensity levels.

It will be apparent to those skilled in the art that various modifications and variations can be made in the method and system of the present invention without departing from the spirit or scope of the invention. For example, the reflector may be used with many different light sources other than LEDs. Thus, the present invention is not limited by the foregoing descriptions but is intended to cover all modifications and variations that come within the scope of the spirit of the invention and the claims that follow.